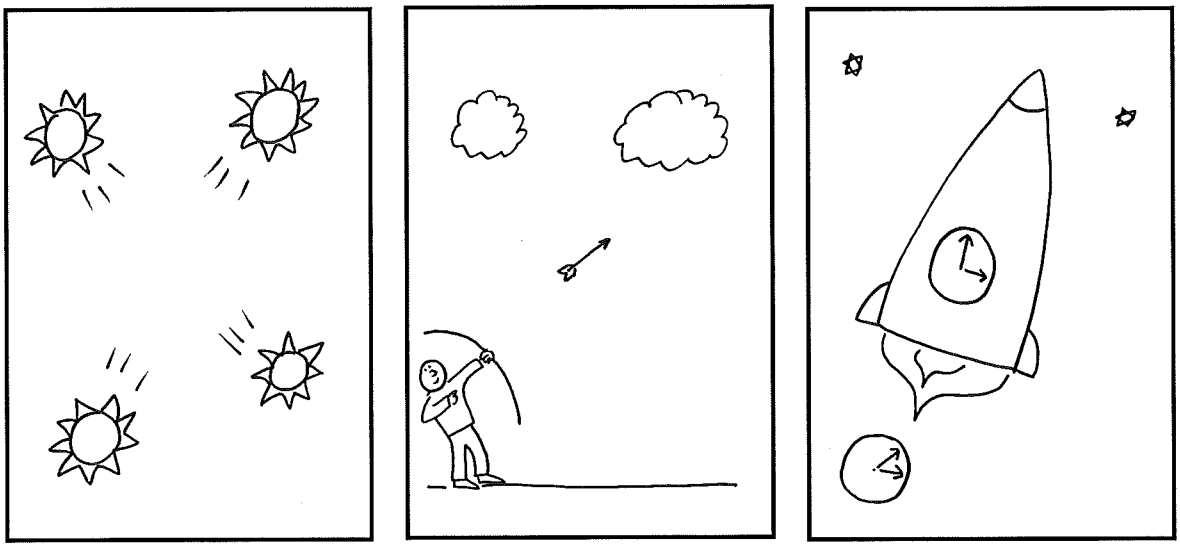
Unit 1

Our Dynamic Universe



Tutorial Questions

Vectors and Scalars

(1) (a) Which quantities are defined by their size and direction?
(b) Which quantities are defined by only their size?
(c) From this list write down the vector quantities

Time Volume Weight Mass Friction

(2) For each of these 4 journeys sketch the journey then calculate

(a) The distance travelled (b) The displacement from the start.

() A man walks 20m east then 15 west.

() A girl runs two laps of a 400m long circular running track

() A man walks 12m East, 20m North, 12m West then 8m South.

() A man walks 100m North then 160m South.

(3) A car travels 600m North then 400m East.

(a) What is the distance travelled?
(b) What is his displacement from the start.?

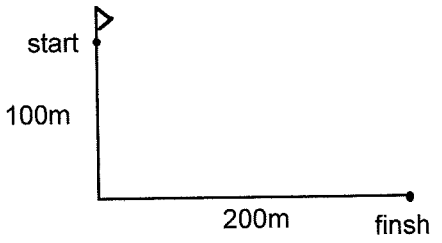
(4) A plane travels 800km West then 500km South

(a) What is the distance travelled
(b) What is his displacement from the start.

(5) A ship travels 78km (090) the 45km (050)

(a) What is the distance travelled
(b) What is his displacement from the start.

(6) A runner travels the following route in 50s.
What is her average (a) speed ($6ms^{-1}$)
(b) velocity ($4.5ms^{-1}$ (117))



(7) A woman runs one lap of a 400m long Olympic running track in 60s

(a) What was her average speed ? (b) What was her average velocity?

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(2)(i)(a)35m (b) 5m east (ii)(a) 800m (b) 0m (iii)(a) 52m (b) 4m north (iv)(a) 260m (b) 60m south
(3)(a) 1000m (b) 721m(034) (4)(a) 1300km (b) 943km(238) (5)(a) 123km (b) 116km (076)
(7)(a) $6.7ms^{-1}$ (b) $0ms^{-1}$

(8) A runner travels 300m south then 250m (270) in a time of 2mins.

(a) distance travelled. (550m)
(b) average speed of runner. ($4.6ms^{-1}$)
(c) displacement from start. 390.5m (220)
(d) average velocity of runner. ($3.3ms^{-1}$)

(9) A motor boat travels 50km(270) then 30km(300) in 3hrs. Calculate

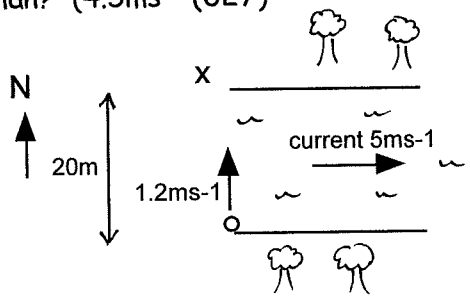
(a) distance travelled in km (80km)
(b) average speed of runner in kmh-1 ($26.7kmh^{-1}$)
(c) displacement from start 77.5km (281)
(d) average velocity of runner. ($25.8kmh^{-1}$ (281)

Velocity as a vector

(1) A boat travels east at a velocity of $5ms^{-1}$. Wind blows from west to east at $2ms^{-1}$. By adding the vectors together nose to tail state the resultant velocity of the boat?

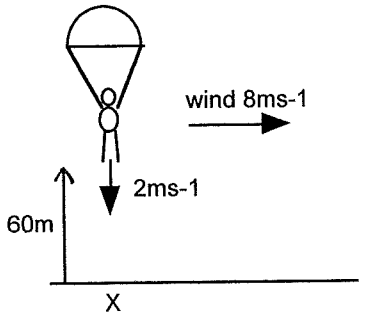
(2) A man walks North along a road with a velocity vector of $4ms^{-1}$. If the wind blows from the west at $2ms^{-1}$ what is the resultant velocity of the man? ($4.5ms^{-1}$ (027)

(3) A swimmer swims at $1.2ms^{-1}$ (North) across a 20m wide river as shown. The river flows due East at $5ms^{-1}$.



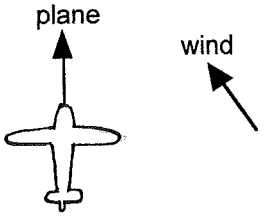
(a) How long will it take him to reach opposite bank?
(b) How far from point X will he land
(c) What is his velocity vector?

(4) A parachutist descends vertically at a constant $2ms^{-1}$
The wind blows across him as shown.



(a) How long will it take him to land?
(b) How far from point X will he land?
(c) What is his velocity vector?

(5) A plane travels north at $36ms^{-1}$. If the wind blows at at $12ms^{-1}$ (320) calculate its resultant velocity?
($45.8ms^{-1}$ (350))



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(1) $7ms^{-1}$ (to east or 090) (3)(a) 16.7s (b) 83.5m (c) $5.1ms^{-1}$ (077) (4)(a) 30s (b) 240m
(c) $8.2ms^{-1}$ (14^{o} below horizontal)

Equations of Motion

(1) A car accelerates from rest to $18ms^{-1}$ in 2.4s. What is the acceleration? ($7.5ms^{-2}$)

(2) A motor boat travelling at a constant speed of $12ms^{-1}$ accelerates at $3.2ms^{-2}$ for a time of 5s. What is the final speed? ($28ms^{-1}$)

(3) An aeroplane, originally at rest accelerates along a runway at $2.4ms^{-2}$. After traveling 580m it takes off. What is the speed of the plane at take off? ($52.8ms^{-1}$)

(4) A runner starting from rest accelerates at $1.8ms^{-2}$ for 3s. How far does he travel? (8.1m)

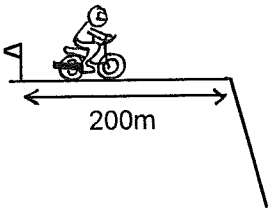
(5) A tennis ball launcher is 0.6m long. A tennis ball leaves the end with a speed of $30ms^{-1}$.

(a) Calculate the average acceleration of the ball in the rocket. ($750ms^{-2}$)
(b) How long does the ball accelerate in the launcher? (0.04s)

(6) A rocket in space has a constant speed of $50ms^{-1}$. the rockets are fired and it accelerates at $0.6ms^{-2}$ for 2mins

(a) Calculate how far it travels in this time. (10,320m)
(b) Calculate the final speed of the rocket. ($122ms^{-1}$)

(7) A daredevil motorcyclist accelerates towards the edge of a cliff. He passes a flag 200m from the edge of the cliff and accelerates at $3.8ms^{-2}$. If he takes off from the cliff edge at a speed of $54ms^{-1}$ calculate the speed he passes the flag. ($37.4ms^{-1}$)



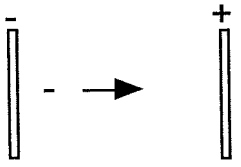
(8) A motorboat accelerates at $1.7ms^{-2}$ from rest and covers 46m. How long did it take him to cover this distance? (7.4s)

(9) In a speed trial a car passes a light gate with a speed of $20ms^{-1}$ then passes a second light gate with a speed of $78ms^{-1}$. The average acceleration between the gates is $4.5ms^{-2}$

(a) Calculate the distance between the gates. (632m)
(b) How long did it take her to travel between the gates? (12.9s)

(10) A rocket taking off from Cape Canaveral has an average acceleration of $8ms^{-2}$. How long would it take to reaches a height of 6km? (38.7s)

(11) An electron accelerates from rest across an electric field to a speed of $1.7 \times 10^5 ms^{-1}$ in a time of $1.2\mu s$. How far a part are the positive and negative plates. (hint - 2 parts) (0.1m)



Deceleration questions

(1) A plane touches down on a runway at a speed of $120ms^{-1}$. After travelling 1500m along the runway it comes to rest. What is the average acceleration? $(-4.8ms^{-2})$

(2) A train enters a station with a speed of $15ms^{-1}$ and decelerates to rest at $0.75ms^{-2}$

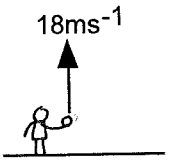
(a) Calculate the time it takes the train to come to rest. (20s)
(b) How far did the train travel while decelerating (150m)

(3) A stunt car enters a movie set with a speed of $24ms^{-1}$ and decelerates at $2.2ms^{-2}$ to a speed of $12ms^{-1}$. How far did it travel during the deceleration? (98m)

Free fall - objects moving under gravity. If up is positive then $a = -9.8ms^{-2}$

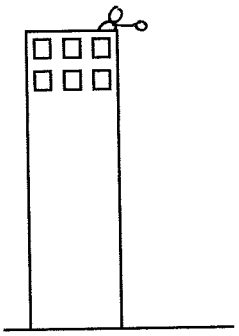
(1) A girl throws a ball vertically upwards. The ball leaves her hand with a velocity of $18ms^{-1}$.

(a) Calculate the time it takes to reach the highest point. (1.8s)
(b) Calculate the maximum height it reaches. (16.5m)
(c) Calculate the velocity after 3s. (Why is it negative) $(-11.4ms^{-1})$
(d) What will its velocity be when the girl catches it? $(-18ms^{-1})$



(2) A man drops a ball from rest off the top of a building.
It hits the ground after 6.2s

(a) What is the velocity of the ball just as it hits the ground?
(b) Why is the velocity negative?
(c) The next question asks you to calculate the height of the building. But what value in your equation of motion will you be calculating to allow you to know the height
(d) What is the height of the building?



(3) An arrow is fired directly upwards and reaches a height of 40m then falls to Earth

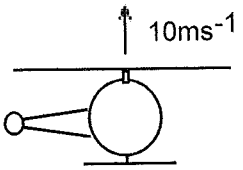
(a) At what velocity does it leave the bow. $(28ms^{-1})$
(b) What time did it take to reach the maximum height. (2.9s)
(c) Fo how long was the arrow in the air? (5.8s)

(4) A boy drops a stone down a 78m deep well. At what velocity did it hit the bottom of the well. (careful about choosing the sign) $(-39ms^{-1})$

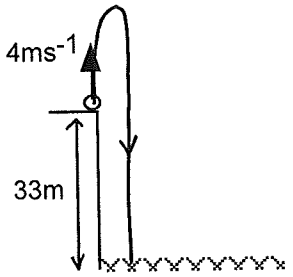
(5) A boy <u>throws</u> a stone vertically downwards off a 18m high bridge. If it leaves his hand with a speed of $12ms^{-1}$ calculate the time it takes to hit the river? (hint - 2 parts) (1s)

(2)(a) $-60.8ms^{-1}$ (d) 188m

(6) A helicopter is rising at a speed of $10ms^{-1}$ when a spanner falls of the helicopter. If the spanner hits the ground after 8s calculate the height of the helicopter just as the spanner leaves the helicopter. (hint draw a diagram showing path of spanner). $(233.6ms^{-1})$



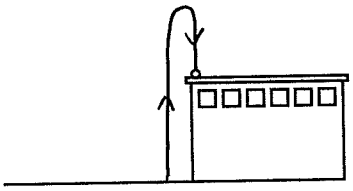
(7) A ball is thrown vertically upwards from the edge of a cliff as shown.



(a) What is the velocity off the ball when it hits the water? $(-25.7ms^{-1})$

(b) How long is the ball in the air? (3s)

(8) A ball is thrown vertically upwards with a velocity of $24ms^{-1}$ and lands on the roof of a building after 4s. What is the height of the building? (17.6m)



(9) A student wishes to measure the acceleration due to gravity in her class. She drops a mass from a height of 3m and measure the time it takes to hit the ground as 0.9s

(a) What value would this give her for acceleration due to gravity? $(-7.4ms^{-2})$

(b) She choose between two objects - A☐ B▯ Explain which one she should have chosen.

(c) State 2 other things she could have done to reduce the uncertainty in her measurement of time?

(10) A student drops a stone from the window of her class room. Six friends measure the time it took to hit the ground. The results are given below.

1.78	1.88	1.99	1.54	1.64	1.83

(a) Calculate the mean time.

(b) Calculate the random uncertainty in the values.

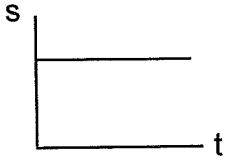
(c) The reading uncertainty is 0.01s. Which uncertainty would you use as a good approximation to the uncertainty in time - the random or reading? Explain.

Displacement - Time graphs.

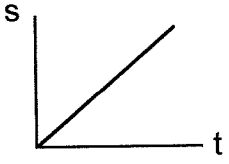
(1) Look at these displacement graphs.

Which one shows a object (a) at rest (b) moving with constant speed (c) accelerating

A



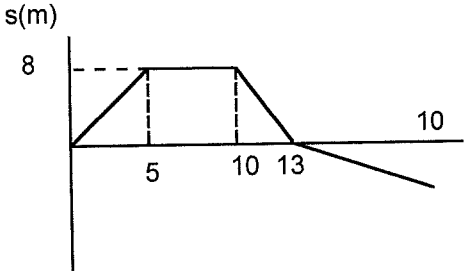
B



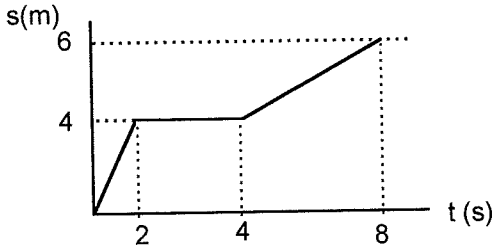
C

(2) Look at this displacement time graph of a boy going for a walk due North from a tree.

(a) How far away from the tree is he after 5s?
(b) What is he doing between 5 and 10s
(c) Where is he at time 13s
(d) What is he doing after 13s

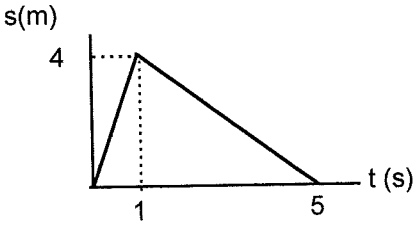


(3) Look at this displacement time graph



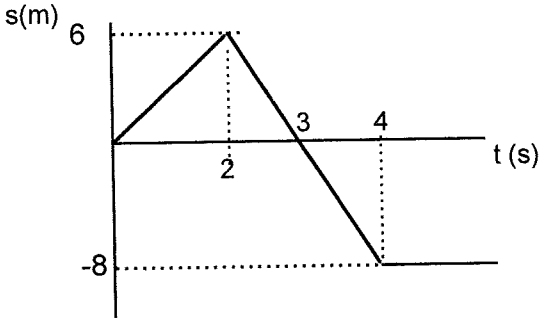
(a) What is the velocity 0-2s?
(b) What velocity during 2 - 4s?
(c) What is velocity 4-8s?

(4) Look at this displacement time graph of a person going for a walk.



(a) How far from the start is she he at 1s?
(b) What is he doing after 1s.
(c) At what time is it back at the start?

(5) This displacement time graph shows the motion of an object. It starts off moving to the right.

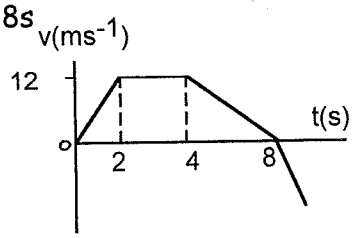


(a) How far is object from start at 2s?
(b) What does object do from 2-3s
(c) What does object do 3-4s.
(d) Calculate the velocity 0-2, 2-4s

(1)(a) B (b) C (c) A (2) (a) 8m (b) stationary (c) back at tree (d) moving in opposite direction (3)(a) $2ms^{-1}$ (b) $0ms^{-1}$ (c) $0.5ms^{-1}$ (4)(a) 4m (b) walking back to start. (c) 5s (5)(a) 6m (b) travel back to start (c) move to left (d) $3ms^{-1}$ $-7ms^{-1}$

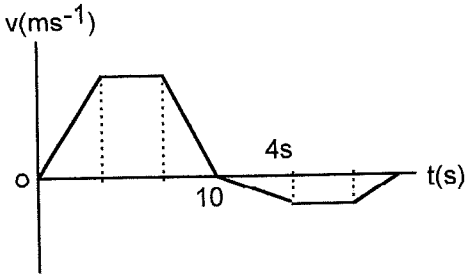
Velocity time graphs

(1) This velocity time graph shows the motion of a cyclist over 8s



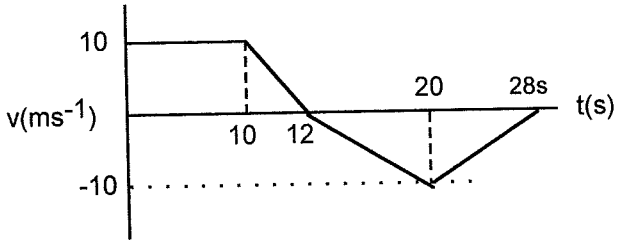
(a) Calculate her acceleration 0-2s
(b) Describe her motion 2-4s
(d) Calculate her acceleration 4-8s
(e) Calculate the displacement of the object after 4s.
(f) What does she do after 8s?

(2) This velocity time graph show the motion of a car. Positive velocities are due North



(a) What direction was she travelling in the first 10s?
(b) What did the car do at 10s?
(c) What did she do in the next 4s
(d) How can you tell from the graph she travelled further north than south

(3) This velocity time graph show the motion of an object.

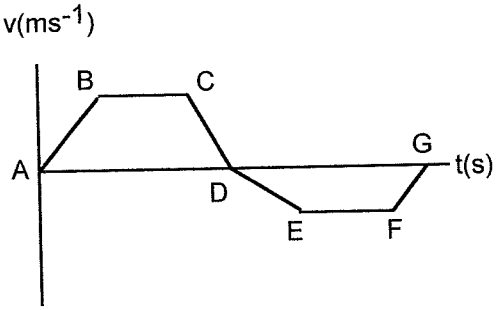


(a) What is the total distance travelled?
(b) Therefore what is her average speed?
(c) What is the final displacement from the start?
(d) Calculate her average velocity.

(1)(a) $6ms^{-2}$ (b) constant velocity of $12ms^{-1}$ (c) $-3ms^{-2}$ (d) 36m (2)(a) North (b) turn South (c) accelerate south (d) larger area under graph above axis (3)(a) 190m (b)$6.8ms^{-1}$ (c) 30m (d) $1.1ms^{-1}$

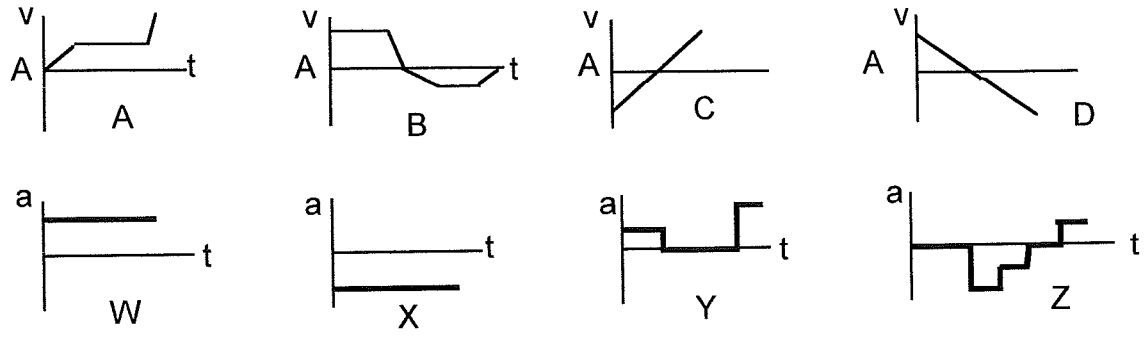
Velocity to Acceleration - time graphs

(1) Look at this velocity time graph. To the right is positive

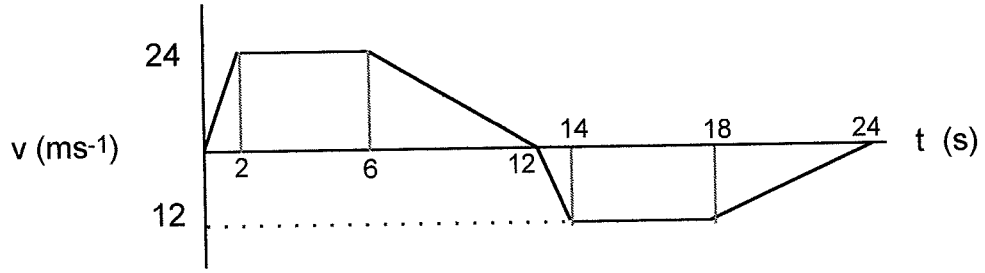


(a) Which part show the object accelerating to the right
(b) Which part shows the object accelerating to the left
(c) Which part show the object travelling at a constant speed to the right
(d) Which part shows the object decelerating to the left
(e) Sketch the acceleration time graph to illustrate the motion.

(2) Match up the 4 velocity time graphs A-D with the correct acceleration - time graphs W-Z



(3) For this graph work out the accelerations and sketch the acceleration time graphs



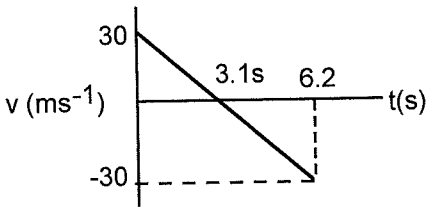
(1) A-Y B - Z C - W D - X (2)(a)AB (b) DE (c) BC (d) FG

Free fall graphs.

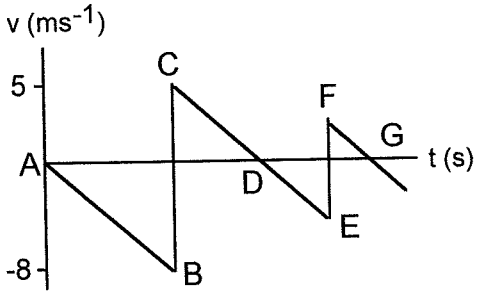
(1) If a ball is in free fall what will its acceleration be at all points?

(2) This graph show the velocity of an object thrown vertically upwards and caught.

(a) At what velocity did the ball leave his hand?
(b) What is the acceleration on the way up?
(c) What is the acceleration on the way down?
(d) Sketch the acceleration - time graph.
(e) What is the maximum height of the ball?



(3) This graph shows a ball being dropped from rest and bouncing.



(a) What happens between A and B?
(b) What happens between C and D?
(c) What happens between D and E
(d) Why is the speed at C less than at B?
(e) Why are the gradients of AB, CE and FG all the same?
(f) Sketch the acceleration-time graph. (hint it is always in freefall)

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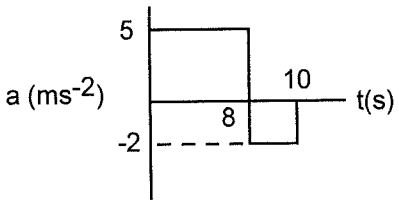
(1) $-9.8ms^{-2}$ (2)(a) $30ms^{-1}$ (b) $-9.8ms^{-1}$ (c) $-9.8ms^{-2}$ (e) 46.5m (3)(a) accelerating downwards (b)decelerating upwards (c) accelerating downwards (d) kinetic energy lost in bounce (e) all -9.8ms-2

Acceleration time graphs

(1) This acceleration-time graph shows an object moving in one direction from rest.



(a) Work out in your head the velocity of the object after 10s. ($36ms^{-1}$)

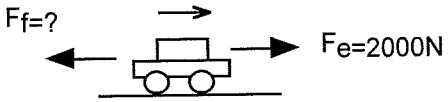
(a) Sketch the velocity time graph

Forces - Revision

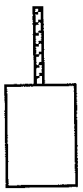
(1) Here are Newtons 3 laws. State which is the 1st, 2nd and 3rd. for example A = 1st

A - An unbalanced force will cause a mass to accelerate
B - If the forces on an object are zero or balanced its motion will not change.
C - If A applies a force to B then B applies and equal and opposite force on A.

(2) A car travels along a motor way at a constant speed. If the engine force is 2000N what is the frictional force? (-2000N)

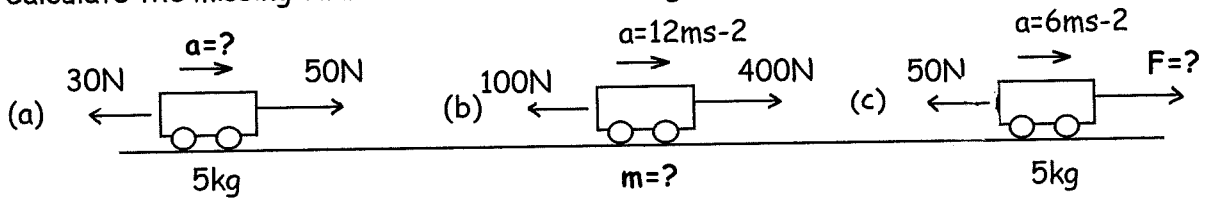


(3) A lift has a mass of 800kg. It moves upwards at a constant speed



(a) What is the weight of the lift? (7840N)
(b) Draw a freebody diagram showing the two forces
(c) What is the upward tension in the cable? (7840N)

(4) Calculate the missing value **in bold** in these 3 diagrams. Arrow show direction of travel.



(5) A 700kg car accelerates at $1.5ms^{-2}$. The frictional force is 1000N.

(a) Draw a freebody diagram showing the frictional and engine forces.
(b) Calculate the unbalanced force.
(c) Calculate the engine force.

(6) Two boys push an 80kg boulder each with a force of 100N.

(a) Draw a free body diagram.
(b) If frictional forces are 180N calculate the acceleration.

---

(3)(a) $4ms^{-2}$ (b)25kg (c) 80N (5)(b) 1050N (c) 2050N (c) $0.25ms^{-2}$

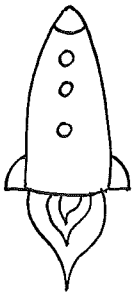
(7) A 500kg motorboat accelerates from rest to 22ms^{-1} in a time of 5.5s.

(a) Calculate the unbalanced force on the boat. (4ms-2)
(b) If friction amounts to 1000N what is the engine force? (3000N)

(8) A 2000kg aeroplane's engines produce a thrust of 26,000N and allow it to accelerate at 3ms^{-2}.

(a) Draw a free body diagram showing the engine and frictional forces.
(b) What is the unbalanced force on the plane? (6000N)
(c) What is the size of the frictional force. (20,000N)

(9) A rocket of mass 4x10^{4}kg is launched vertically upwards. The engines apply a constant thrust of 7x10^{5}N. (ignore air friction)



(a) Draw a free body diagram showing the forces at take off
(b) Calculate the initial acceleration of the rocket. (Hint - weight) (7.7ms^{-2})
(c) As the rocket rises the thrust remains constant . State 2 reasons why the acceleration increases with time.
(d) Explain why a rocket can travel to Mars and not require to burn up any fuel until it arrives at Mars?

(10) A rocket takes off from Earth and accelerates to 90ms^{-1} in a time of 4s. The resultant or unbalanced force is 40kN upwards.

(a) Calculate the mass of the rocket. (hint find acceleration) (1778kg)
(b) Draw a freebody diagram showing the thrust, weight and this time, the frictional force.
(c) If the average frictional force is 5kN calculate the upward engine thrust. (62,424N)

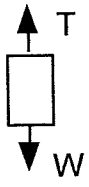
Lift motion

In these examples we will make upwards the positive direction

(1) Choose +ve or -ve for each example:

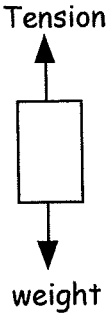
(a) If an object accelerates upwards then acceleration is +ve or -ve
(b) If an object accelerates downwards then the acceleration is +ve or -ve
(c) If an object decelerates upwards then acceleration is +ve or -ve
(d) If an object decelerates downwards then the acceleration is +ve or -ve

(2) A 900kg lift travels upwards at a **constant speed.**



(a) Calculate the weight of the lift. (8820N)
(b) State the tension in the cable (8820N)

(3) A lift travels from the ground floor to the top floor of a department store, then back down For each section of the journey if you think tension is the biggest force write T. If you think weight is the biggest force write W or if you think the forces are are balanced write B



(a) When sitting stationary at the ground floor
(b) Accelerating upwards
(c) Travelling up with a constant speed
(d) Decelerating as it approaches the top floor
(e) Accelerating back down
(f) travelling down at a constant speed
(g) Decelerating to the bottom floor

(4) A 700kg lift accelerates upwards. If the tension is 7500N calculate the acceleration of the lift. ($0.91ms^{-2}$)

(5) The 700kg lift decelerates towards the top floor at $0.8ms^{-2}$. What is tension in the cable this time. (6300N)

(6) On the way down from the top floor the 700kg lift accelerates and the tension in the cable is 6000N calculate the acceleration. ($-1.22ms^{-2}$)

(7) As the 700kg approaches the bottom floor it decelerates at $0.7ms^{-2}$. What is the tension in the cable at this point. (7350N)

(8) In which two parts of the motion of the lift would the tension be greater than the weight

Bathroom scales

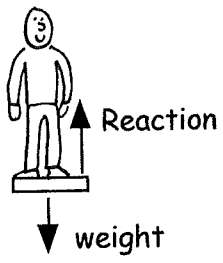
(1) A woman stands on a set of bathroom scales in her house. The scales read 600N.

(a) Is this her weight or the reaction force she is reading?
(b) Why can she say that this is her weight?

(2) In a lift moving at a constant speed a man stands on a set of bathroom scales. The scales read 800N. What is his weight?

(3) In a lift accelerating upwards at $2ms^{-2}$ a 70kg man stands on a set of scales.

(a) Calculate the man's weight. (686N)
(b) Calculate the reading on the scales. (826N)

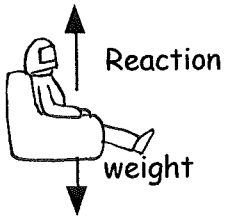


(4) A man of mass 60kg stands on a set of scales in a lift. The lift accelerates upwards and the scales read 620N What is the acceleration of the lift ($0.53ms^{-2}$)

(3)(a) B (b) T (c) B (d) W (e) W (f) B (g) T

(5) The lift accelerates downwards at $0.9ms^{-2}$. What is the reading on the scales. (534N)

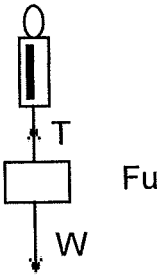
(6) A 70kg astronauts is strapped into his seat. At take off the acceleration of the rocket is $5.2ms^{-2}$. What reaction force would she feel pushing up on her through the chair? (1050N)



Newton Balances

(1) When a mass is hung from a newton balance what is it the balance is actually reading

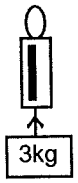
A - the unbalanced force
B - the tension in the wire holding the mass or
C - the weight of the mass



(2) A 3kg mass is hung on a Newton balance in a lift. The reading on the balance reads 33N.

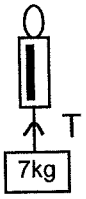
(a) Calculate the acceleration of the lift. ($1.2ms^{-2}$)

(b) As the lift approaches the top floor it decelerates at $0.4ms^{-2}$. What would be the reading on the Newton balance. (28.2N)



(3) A 7kg mass is hung on a Newton balance in a lift. The lift <u>accelerates downwards</u> at $0.8ms^{-2}$.

(a) Which force is greater, the upward tension as read by the balance or the weight?
(b) Calculate the unbalanced force on the mass (5.6N)
(c) State the reading on the balance (63N)



(4) An astronaut taking off from the moon holds a 4kg mass on a Newton balance. If the rocket accelerates upwards at $5ms^{-2}$ calculate the reading on the balance. (g on the moon = $1.6Nkg^{-1}$) (26.4N)

(5) A crane on a harbour lifts a 5000kg crate out of the hold of a ship. The tension in the cable is 51000N at one point. What is the acceleration of the crate. ($0.4ms^{-2}$)

OPEN ENDED QUESTIONS

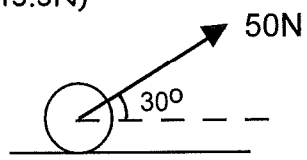
1. A science fiction writer states "You can create 'artificial' gravity in deep space by accelerating the space craft." Use your knowledge of physics to comment on this statement. You can show some calculations to back up thoughts.

Resolution of forces

(1) If an object moves along a horizontal desk it is important that the forces we use in calculations are in the (a) vertical (b) horizontal or (c) the original oblique angle .

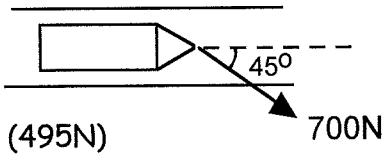
(2) A man pulls a 60kg garden roller with a force of 50N as shown.

(a) Find the horizontal component of the 50N force. (43.3N)
(b) Why do we use this force in calculations involving the motion of the roller?
(c) How can this component be increased without increasing the 50N force
(d) If the frictional force is 41N calculate the initial acceleration of the roller. ($0.046ms^{-2}$)



(3) A barge is pulled along a canal with a rope as shown

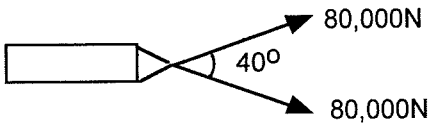
(a) Calculate the component of the force in the direction of motion. (495N)
(b) If the barge travels at a constant speed what is the frictional force on the barge?



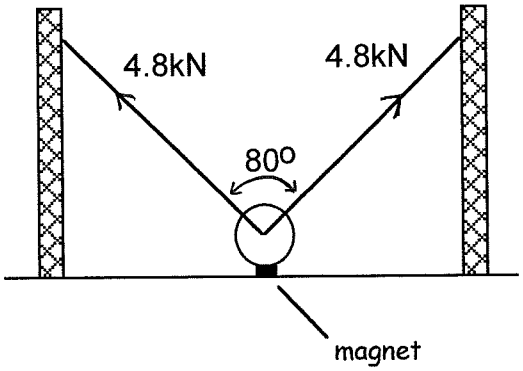
(495N)

(4) An ocean liner of mass 70,000kg is pulled into a harbour by two tugs as shown

(a) Calculate the horizontal force on the liner due to two tugs (150,351N)
(b) If the liner accelerates at $0.06ms^{-2}$ calculate the frictional force on the tug (146,151N)



(5) At a fun fair a pod is launched vertically using two stretched elastic ropes.
The pod is held in place by a magnet which applies a downward magnetic force.
A pod with two passengers has a mass of 450kg



(a) Calculate the total upward vertical force on the pod caused by the elastic ropes.
(b) Draw a free body diagram showing the 3 forces acting on the pod when it is stationary
(c) Just before it is released what is the total downward force on the pod?
(d) Calculate the initial acceleration just as the magnet is switched off
(e) Why does the acceleration decrease as it rises?

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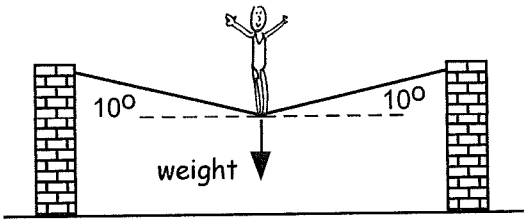
(5)(a) 7354N (c) 7354N (d) $6.5ms^{-2}$

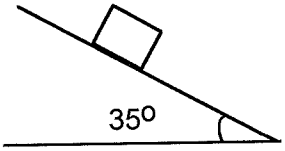
(6) A 48kg gymnast stands in the centre of a high wire rope as shown



(a) Calculate the tension in each side of the rope. (1355N)
(This is the opposite of the above questions - work backwards)

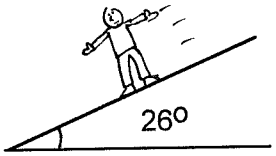
Inclined Plane

(1) A 4kg box sits stationary on an inclined plane as shown



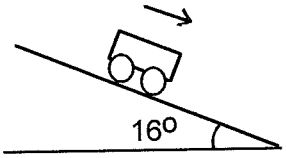
(a) Calculate the component of the boxes weight acting down the slope (22.5N)
(b) What is the force of friction (22.5N)

(2) This 38kg boy slides down a slide with a constant speed



(a) Calculate the component of the boys weight acting down the slope (163.3N)
(b) What is the force of friction? (163.3N)

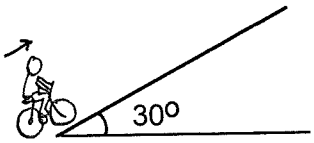
(3) A 2kg trolley rolls down a slope as shown. The frictional forces amount to 3N



(a) Calculate its acceleration. ($1.2ms^{-2}$)
(b) If it starts from rest and the slope is 3m long what is its speed at the bottom? ($2.7ms^{-1}$)

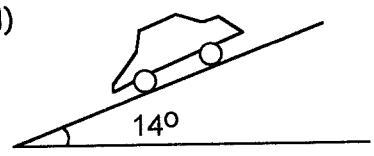
(4) A cyclist and bike of mass 80kg gets to the bottom of a hill with a speed of $15ms^{-1}$. On the hill she stops peddling. and friction amounts to 120N.

(a) Draw a freebody diagram showing the 2 forces on her on the hill.
(b) Calculate the total force acting down the slope. (512N)
(c) Calculate her deceleration. ($-6.4ms^{-2}$)
(d) How far up the slope will she freewheel before coming to a halt (hint - equations of motion) (17.6m)



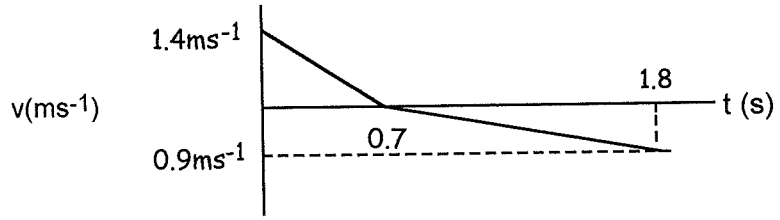
(5) A car of mass 600kg freewheels down a slope inclined at 14° to the horizontal. It accelerates at $2ms^{-2}$

(a) Calculate the unbalanced force on the car. (1200N)
(b) Calculate the frictional force on the car. (Hint - draw a free body diagram). (222.5N)
(c) Explain how increasing the angle affects the acceleration.



(6) A 2000kg truck travels up a slope inclined at 18° above the horizontal with a constant speed. If friction amounts to 5000N calculate the size of the engine force. Draw a free body diagram. (11,057N)

(7) This graph show the velocity of a trolley as it freewheels up a slope then stops and rolls back down to the bottom. (Up slope = positive direction)

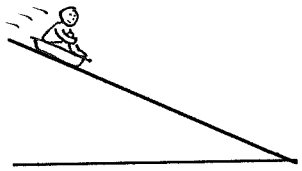


(a) Calculate the acceleration of the trolley on the way up. ($2ms^{-2}$)

(b) Calculate the acceleration when it rolls back down. ($-0.8ms^{-2}$)

(c) By drawing freebody diagrams showing the forces on the trolley as it travels up then down the slope account for the difference in the size of the accelerations.

(8) A boy on a sledge starts his slide from half way down the hill shown.
He decides to start the next slide at the top of the hill because "the acceleration will be greater".
Friction remains constant.

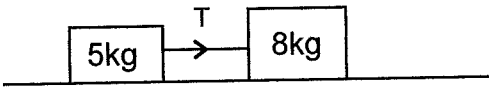


(a) State if starting at the top will increase his acceleration.

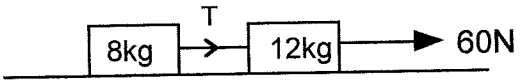
(b) Why will the speed at the bottom be greater?

Multiple mass systems

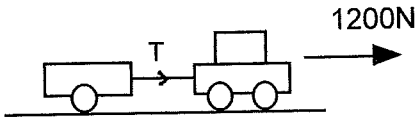
(1) This system is accelerating at $2ms^{-2}$ to the right on a frictionless surface.
Calculate the tension in the cable. (10N)



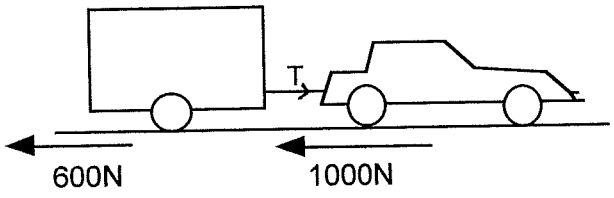
(2) Look at this system. Calculate the tension in the cable when it accelerates along a frictionless surface. (24N)



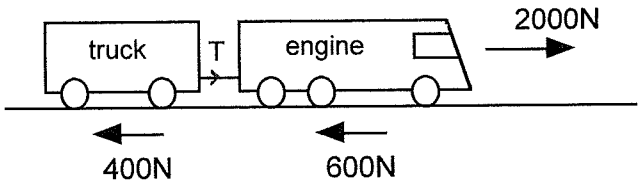
(3) A 900kg car pulls a 500kg trailer along a frictionless surface as shown. If the engine force is 1200N calculate the tension in the cable. (428.5N)



(4) This car and caravan are travelling at a **constant speed**. The friction on the caravan and car is shown. What is the tension in the cable?
(600N)



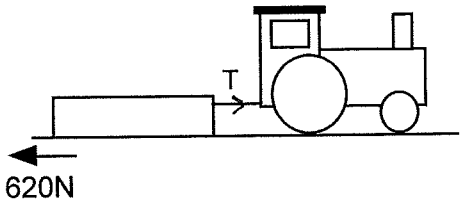
(5) A 4000kg train engine pulls a 3000kg truck. The engine force was 2000N. Friction acting on the train was 600N and the truck was 400N.



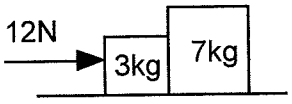
(a) Calculate the acceleration of the system. ($0.14ms^{-2}$)

(b) Therefore calculate the tension in the cable. (820N)

(6) This tractor is pulling a 200kg log. The tension in the cable is 680N. The frictional force on the log was 620N calculate its acceleration (Hint - look at the log) ($0.3ms^{-2}$)



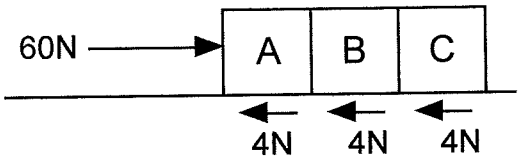
(7) A force of 12N is applied to this block as shown. calculate the force the 3kg block applies to the 7kg block (8.4N)



(8) A force of 60N is used to push three 8kg blocks as shown. The friction on each block is 4N.

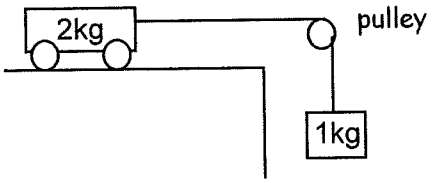
(a) Calculate the acceleration of the system.
(b) Calculate the force block A applies to B & C.
(c) Calculate the force block B applies to C

(a) $2ms^{-2}$ (b) 40N (c) 20N



(9) A 2kg trolley is connected to a 1kg mass as shown. The bench and pulley are frictionless.

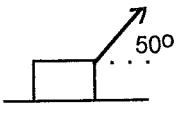
(a) Calculate the weight of the mass. (9.8N)
(b) Calculate the acceleration of the system. ($3.3ms^{-2}$)
(c) Calculate the tension in the cable. (6.6N)



OPEN ENDED QUESTIONS

For each statement use your knowledge of Physics to comment

1. A boy pulls a box along the ground with a force of 50N as shown. A friend states " That is a very inefficient way to pull the box"

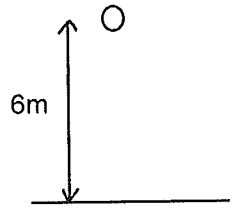


2. A boy pushes a box with a force of 100N. By Newtons 3rd law the box pushes back on him with a force of 100N. He is puzzled why the box moves forward even though the "forces are balanced."

3 A rocket takes off from the ground because the hot gases push on the ground.

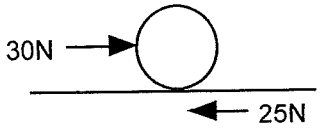
Work, Energy and Power

(1) A 1.4kg ball is dropped from a vertical height of 6m



(a) Calculate the potential energy of the ball at a height of 6m
(b) Use the conservation of energy to work out its speed on hitting the ground. (a) 82.3J (b) $10.8ms^{-1}$

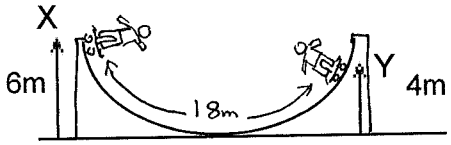
(2) A boy pushes a 20kg rock with a force of 30N a distance of 8m. During this time friction of 25N acts on the rock.



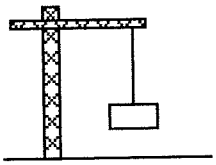
(a) How much work does the boy do? (240J)
(b) How much work does friction do? (200J)
(c) At the end of the 8m how much kinetic energy does the rock have? (50J)

(3) A skate boarder of mass 50kg starts from X and rolls a distance of 18m to point Y.

(a) How much energy was lost in the journey? (980J)
(b) What other forms was it transferred to?
(c) Uses Ew = Fd to calculate the size of the average frictional force. (54.4N)

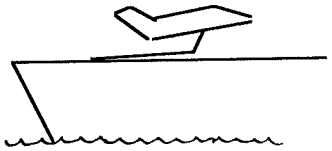


(4) A crane lifts a 70kg box a vertical height of 20m above the ground.



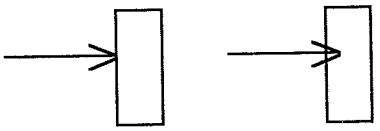
(a) Calculate the gravitational potential energy the box gains
(b) If there was no energy losses how much work does the motor do? (13,720J)
(c) If the lift took 3.9s calculate the power of the motor. (3518W)
(d) In reality why would the power have to be greater to do the lift in 3.9s?

(5) A 3000kg plane lands on an aircraft carrier with a speed of $40ms^{-1}$. The plane hooks onto a large rubber band and the band stretches 34m to bring the plane to a halt



(a) Calculate the kinetic energy of the plane as it touched down. ($2.4x10^{6}$ J)
(b) Calculate the force the rubber band has to apply. (70,588N)

(6) An arrow of mass 22g hits a target at $30ms^{-1}$. The tip travels $3x10^{-2}$m into the target.



(a) Calculate the kinetic energy of the arrow just as it hits the target. (9,9J)
(b) Calculate the average force of the target on the arrow. (330N)
(c) How long did it take the arrow to come to rest after just hitting target. (assume here force is constant) (2 parts) ($2x10^{-2}$ s)

(7) A train applies an engine force of $3x10^{4}$N in diving a train 2km at a constant speed of $10ms^{-1}$. If there are no energy losses what is the power output of the engine? ($3x10^{5}$ W)

Momentum

(1) A car has a mass of 500kg and travels with a velocity of $3ms^{-1}$

(a) What is its momentum of the car?
(b) If the car travels in the opposite direction at the same velocity what is its momentum?

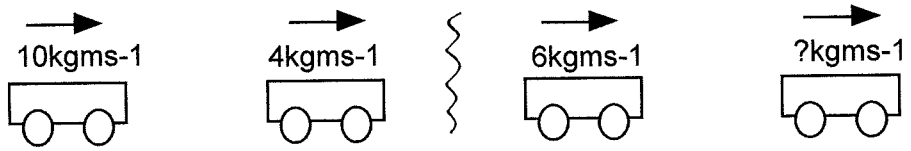
(2) A cyclist ravelling at $18ms^{-1}$ has momentum of $1400kgms^{-1}$. What is her mass? (77.8kg)

(3) A 5kg trolley has 86J of kinetic energy. What is its momentum ($29.3kgms^{-1}$)

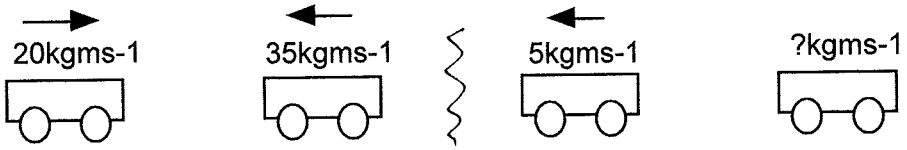
(4) The total momentum of two objects A and B just before they collide is $200kgms^{-1}$. After the collision A has a momentum of $150kgms^{-1}$. What is the momentum of B?

(5) Look at these two collisions- The **momentum** of each object are given before and after the collision

(a)

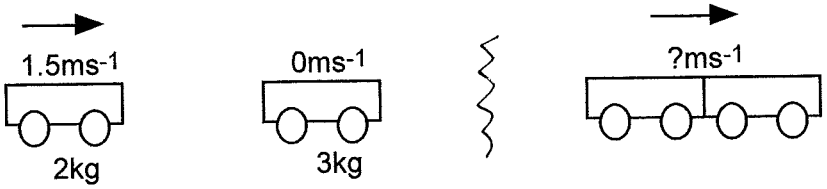


(b)

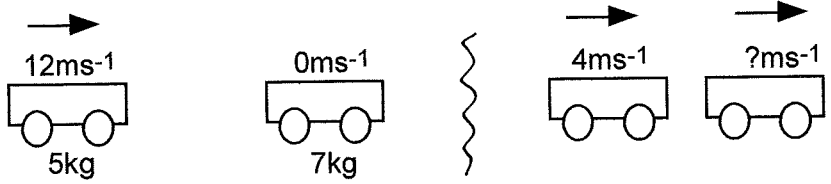


(6) During a collision between two cars, car A's momentum falls from $1000kgms^{-1}$ to $200kgms^{-1}$. If the momentum of car B was $100kgms^{-1}$ before the collision what is is just after the collision?

(7) A trolley of mass 2kg is travelling with a magnitude of $1.5ms^{-1}$. The trolley collides with a stationary trolley of mass 3kg and they stick together. Calculate the velocity of the trolleys immediately after the collision. ($0.6ms^{-1}$)



(8) A 5kg trolley travelling with a speed of $12ms^{-1}$ collides with a stationary 7kg trolley. If the 5kg trolley carries on with a speed of $4ms^{-1}$ in the same direction calculate the velocity of the 2nd trolley. ($5.7ms^{-1}$)



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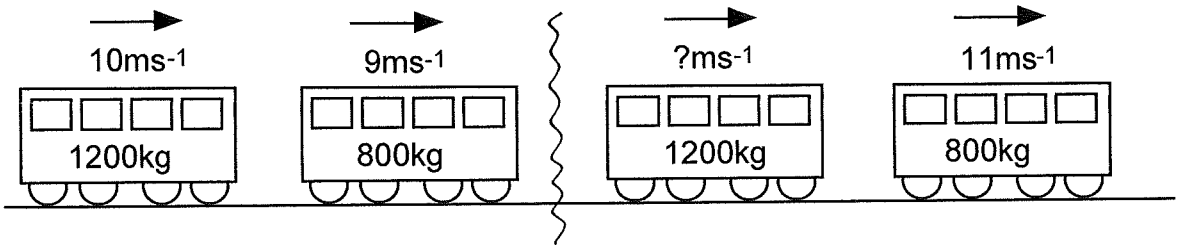
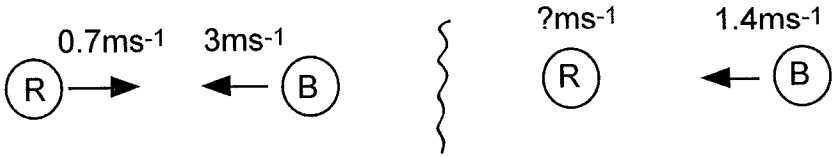
(1) 1500kgms-1 (b) -1500kgms-1 (4) $50kgms^{-1}$ (5)(a) $8kgms^{-1}$ (b) $-10kgms^{-1}$ (6) 900kgms-1

(9) One train carriages collide with one another as shown.



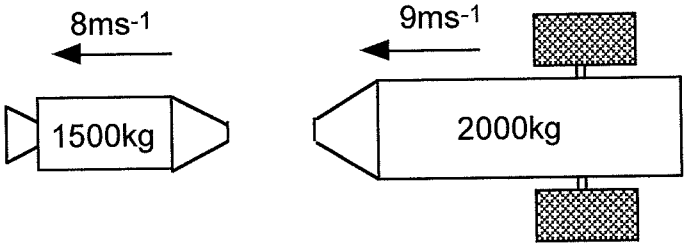
Calculate the final velocity of the 1200kg carriage (8.7ms^{-1})

(10) A red and blue snooker ball each of mass 50g collide as shown.



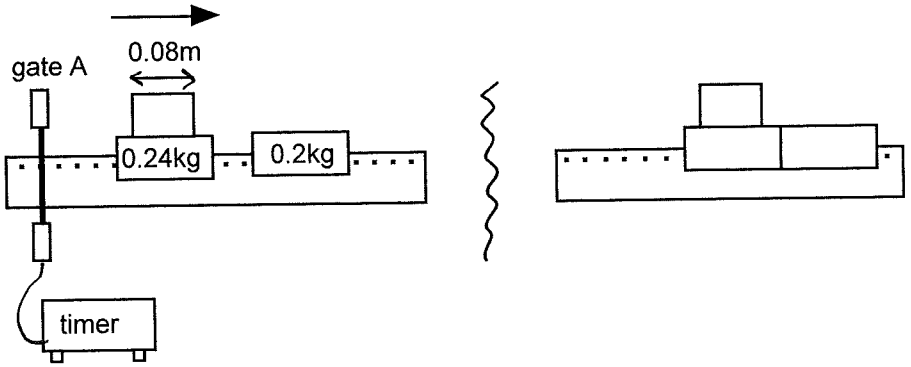
(a) Calculate the final velocity of the red ball. (-0.9ms^{-1})
(b) Show clearly whether this is an elastic or inelastic collision? (inelastic)

(10) Two space vehicles are docking as shown.



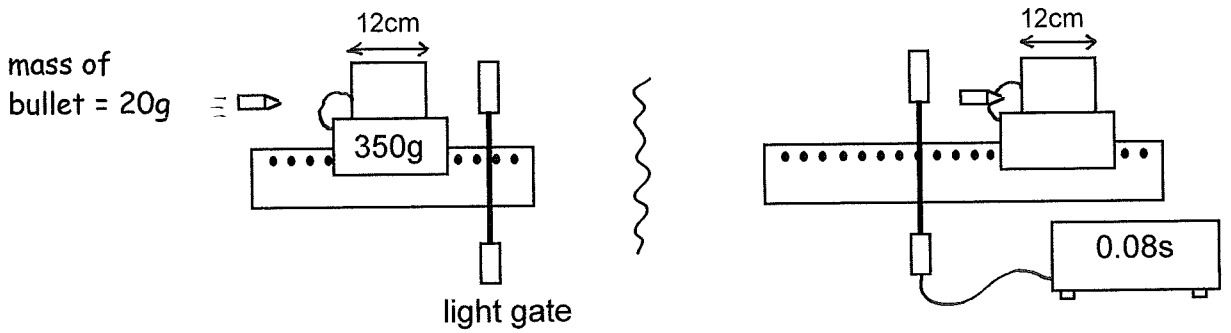
(a) Calculate their combined velocity after docking. (8.57ms^{-1} to left)
(b) Show clearly whether this is an elastic or inelastic collision? (elastic)

(11) In the following experiment the 0.24kg trolley travels through light gate A, collides with and sticks to the 0.2kg trolley. They move off to the right . Use the measurements to calculate the combined speed of the trolleys.



Time measured by timer = 0.19s (0.23ms^{-1})

(12) This set up was used to measure the speed of a bullet. The measurements are shown.

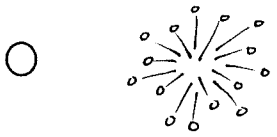


(a) Use the measurements to work out the velocity of the bullet. ($27.8ms^{-1}$)

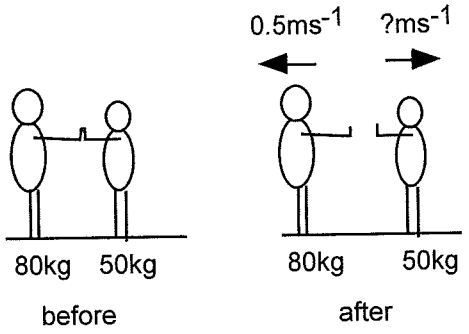
(b) Why is it important to put the light gate as close to the trolley as possible?

Explosions

(1) A stationary objet explodes. What is the total momentum of all the fragments exploding apart.

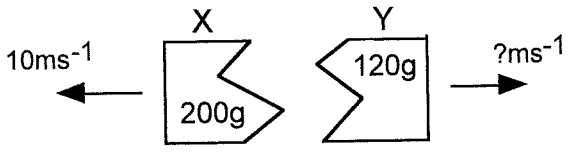


(2) A 80kg man and 50kg woman are standing stationary on ice facing each other.
They push each other apart
The man moves backwards at 0.5ms-1.
What is the velocity of the woman as a result of the push? ($-0.8ms^{-1}$)



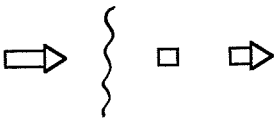
(3) A firework reaches its maximum height and explodes apart as shown. (ie u=0)

What is the velocity of part Y just after the explosion. ($-16.7ms^{-1}$)



(4) Two trolleys A and B are originally at rest and joined together. A spring is released which causes them to come apart in opposite directions. Trolley A which has a mass of 2kg travels off in one direction with a speed of $4ms^{-1}$. The other trolley flies off in the opposite direction with a speed of $2.1ms^{-1}$ (3.8kg)

(5) A 3.8kg firework travelling with a speed of $48ms^{-1}$ explodes into two parts. One part of mass 1.2kg travels on with a velocity of $27ms^{-1}$. What is the velocity of the other piece?



($57.7ms^{-1}$)

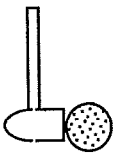
Impulse and change in momentum

(1) If a force F is applied to an object for a time t then what about the object changes?

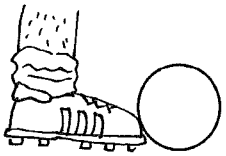
(2) A 10,000kg rockets engines are fired and produce a force of 20,000N for a time 6s.

(a) If the rocket starts from rest what is the final velocity of the rocket. ($12ms^{-1}$)
(b) Would the change and momentum be bigger or smaller if the engines were fired for a longer time.

(3) A golf club hits a 50g ball with an average force of 200N. If the collision acts for 16ms calculate the velocity the ball leaves the club. ($64ms^{-1}$)



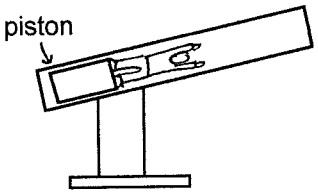
(4) A boy kicks a stationary 0.15kg ball. The foot is in contact with the ball for 0.7s and the ball leaves the boys foot with a velocity of $18ms^{-1}$



(a) Calculate the size of the average force the boy applies to the ball. (3.9N)
(b) What is the impulse of the force? (2.73Ns)
(c) How does this compare to the change of momentum caused?
(d) If the same force is applied but the contact time is longer how does this affect the final velocity of the ball?

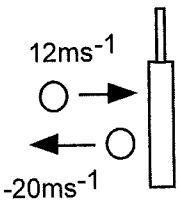
(5) A cue hits a 200g stationary snooker ball with an average force of 7N. If the ball leaves the cue with a velocity of $1.58ms^{-1}$ calculate the time the force acted for? (0.045s)

(6) A 78kg stunt man in fired out of a cannon. An average force of 600N is applied to him by a piston for a time of 0.8s.

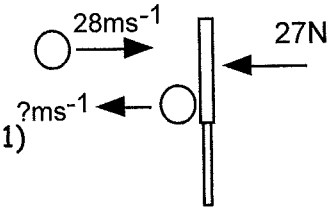


(a) Calculate the speed he leaves the piston. ($6.2ms^{-1}$)
(b) What is the impulse of the force? (480Ns)

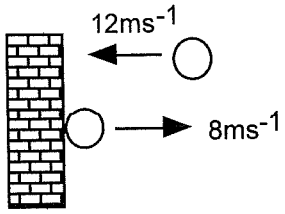
(7) A cricket ball hits a bat with a velocity of +12ms-1. The ball was in contact with the bat for 25ms. If the ball came off the bat with a velocity of -20ms-1 calculate the force on the ball. (-64N)



(8) A 0.022kg tennis ball travels towards a tennis racquet with a speed of $28ms^{-1}$. The player hits it back with an average force of 170N. If the time of contact was 26ms calculate the velocity the ball leaves the racquet.
(Make to the right the positive direction) (-3.9ms-1)
(Hint - this makes the force -ve)

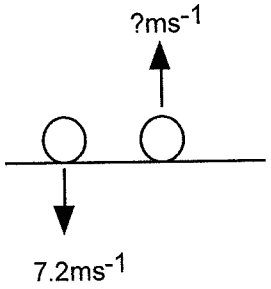


(9) A 0.4kg ball hits a wall with a speed of $12ms^{-1}$. It deflects straight back with a speed of $8ms^{-1}$. The ball was in contact with the wall for 18ms. (Hint - make to right positive)



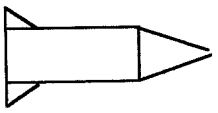
(a) Calculate the average force the wall applied to the ball. (444.4N)
(b) What force did the ball apply to the wall?

(10) A 180g ball is dropped onto the floor and hits the surface with a speed of $7.2ms^{-1}$. If the magnitude of the force the floor applies on the ball is 5N and it lasts for 0.4s calculate the velocity the ball rebounds from the floor. (hint - make up positive direction) $(3.9ms^{-1})$



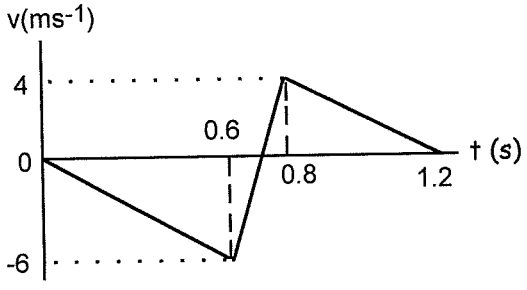
(11) A train of mass 40,000kg enters a station at a velocity of $7ms^{-1}$. If the average braking force is 6000N calculate the final speed of the train after braking for 8s. $(5.8ms^{-1})$ (Hint - what is the sign of the force as it's against the motion?)

(12) A rocket ejects gas at a rate of $50kgs^{-1}$ and at a speed of $1800ms^{-1}$.



(a) Calculate the size of the average force on the gas. (Hint - do problem over 1s) (90,000N)
(b) What is the size of the force on the rocket? (-90,000N)
(c) Which law of physics helps with the above answer?

(13) This graph show the velocity time graph for a 400g ball bouncing off the ground

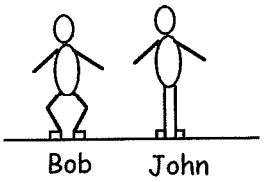


(a) At what velocity does ball hit ground?
(b) At what velocity did ball rebound off the ground?
(c) What time was the ball in contact with the ground
(d) What force did the ground exert on ball

(a) $-6ms^{-2}$ (b) $4ms^{-2}$ (c) 0,2s (d) 20N

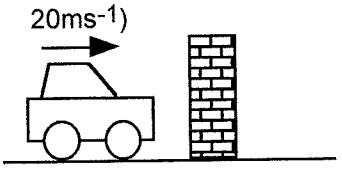
Thinking about altering the force.

(1) Two identical twins jump of the same height of wall and land with the same velocity. Bob bends his legs when he lands. John keeps his legs straight



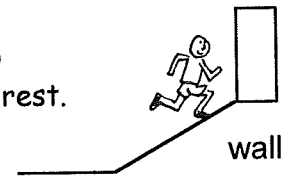
(a) Compare the change of momentum of each as the ground brings them to rest.
(b) Why is the stopping force on John much greater?

(2) A car of mass 600kg travelling at 20ms^{-1} crashes into a wall. The car which has a rigid bonnet is brought to rest in a time of 0.42s (right =+ve)



(a) Calculate the stopping force on the car? (-28,571N)
(b) A 2nd car with the same mass hits the wall with the same speed. This car has a bonnet designed to crumple. If this car came to rest in 1.2s calculate the new stopping force. (-10,000N)

(3) Two indoor sprinters of the same mass end a 60m race, run up the banked track and use the wall at the top to bring them to rest. Runner A uses the wall made of a padded mat to bring her to rest. Runner B uses the concrete wall to bring her to rest



(a) If they both have the same mass and hit the wall with the same speed how do their change of momentums compare as they are brought to rest?
(b) Why is the stopping force on runner B greater than on runner A?

(4) A tennis player is told to follow through when she hits the ball. Show why this is good advice if you want the ball to come off the racquet faster.

OPEN ENDED QUESTIONS

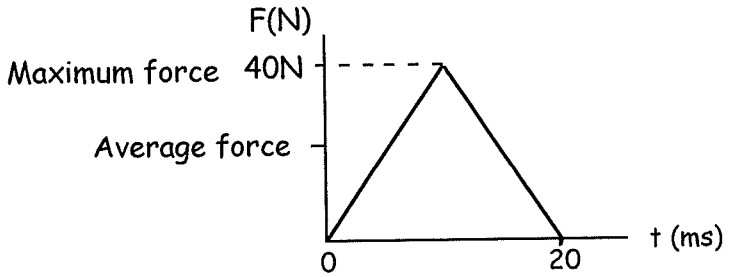
For each statement use your knowledge of Physics to comment

1. A student holds a ball stationary in her hand (zero momentum). She drops it and notices the momentum increases as it accelerates. She states that this is an example of the law of conservation of linear momentum not holding.

2. An old man sees a car which has been involved in a head on collision at the side of the road. He says " Look at how crumpled the car is. They don't build cars like they used to in my day. Cars were built solid and made to last"

Force-time graphs

(1) The following graph show the force on a 0.16kg hockey ball during the time the stick is in contact.



(a) Is the force F used in your formula Ft = mv-mu the average or maximum force.

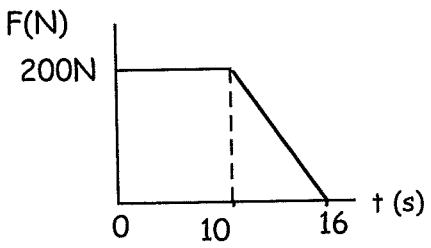
(b) Calculate the area under the graph. ($0.4m^2$)

(c) How does this number relate to the impulse and change of the momentum on the ball? (area = impulse = change in momentum)

(d) Therefore calculate the **<u>average</u>** force on the ball. (20N)

(e) Calculate the final velocity of the ball when it leaves the stick. ($2.5ms^{-1}$)

(2) The force-time graph shows the force on a 25kg object in an engineering process. The object is originally at rest.

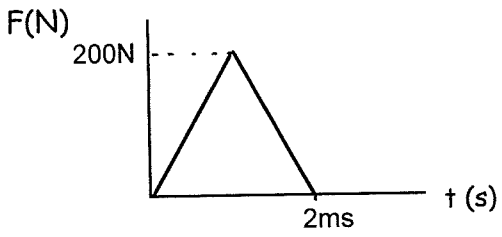


(a) Calculate the change of momentum of the object. ($2600kgms^{-1}$)

(b) Calculate the final velocity of the object. ($104ms^{-1}$)

(c) Calculate the average Force on the object. (162.5N)

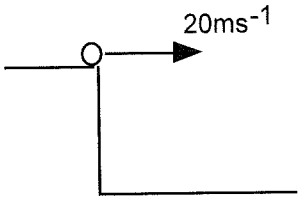
(3) A graph showing the force on a golf ball is given below. Sketch this graph



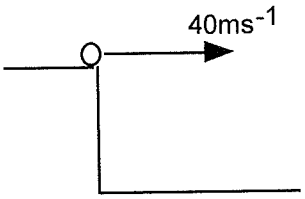
A softer ball of <u>same mass</u> is hit and the ball leaves the club with the same speed. Sketch the new Force time graph on the same axis.

Horizontal projectile motion

(1) A ball is kicked horizontally from the top of a cliff with a horizontal speed of $20ms^{-1}$. It takes 4s to land.



(a) Another ball is kicked with a horizontal velocity of $40ms^{-1}$ from the same cliff. How long will it take to land?

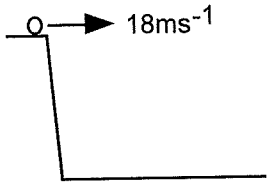


(b) Explain why this is.

(c) A ball is now dropped vertically from the cliff how long will this ball take to hit the ground?

(d) On what does the time a horizontal projectile is in the air depend?

(2) A ball is kicked horizontally from the top of a cliff with a horizontal speed of $18ms^{-1}$. It takes 3.8s to land.



(a) What is the horizontal speed of the ball when it lands

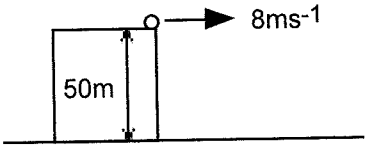
(b) What is the vertical speed of the ball when it lands

(c) What is the resultant speed on landing

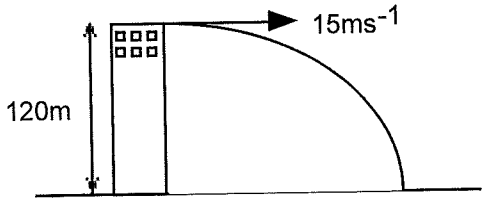
(d) How far did the ball travel horizontally?

(e) What is the height of the cliff

(3) An object is projected horizontally off the top of a building as shown.
Which value and equation will allow you to calculate the time the object is in the air?



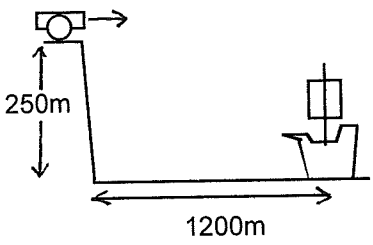
(4) A projectile is fired off the top of a 120m high building with a horizontal velocity of $15ms^{-1}$.



(a) How long was the projectile in the air? (4.9s)

(b) How far horizontally did it travel? (73.5m)

(5) A cannon ball is fired from the top of a 250m high cliff as shown. It requires to travel 1200m from the base of the cliff to hit a Spanish galleon.



(a) How long was the ball in the air? (7.1s)

(b) What horizontal speed was required to hit the galleon. ($169ms^{-1}$)

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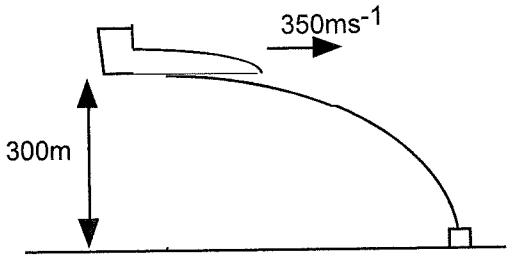
(2)(a) $18ms^{-1}$ (b) $37.2ms^{-1}$ (c) $41.3ms^{-1}$ (64^{o} below Horz) (d) 68.4m (e) 70.8m

(6) An aeroplane travelling at $350ms^{-1}$ releases an aid box at a height of 300m.

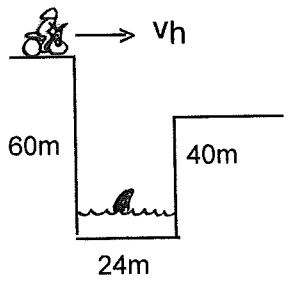


(a) Calculate the time the box is in the air. (7.8s)

(b) How far did it travel horizontally during this time? (2730m)

(c) What is the position of the plane relative to the box just as the box lands?

(7)



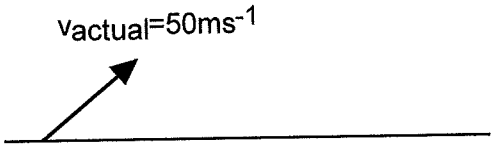
A stuntman has to jump the following ravine on a motorbike.

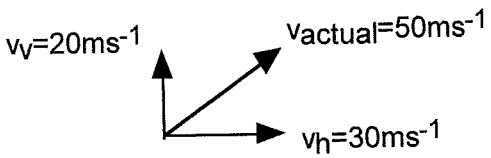
(a) What is the minimum horizontal speed he requires to make the leap? (11.9ms-1)
(Hint how long will he be in the air)

(b) In another spot on the ravine the opposite bank was 50m high. Would the stuntman require a higher or lower take off horizontal speed to make the jump?

Oblique projectile motion

(1) A student works out the initial vertical and horizontal components of an oblique projectile as shown





Write down missing words A,B and C

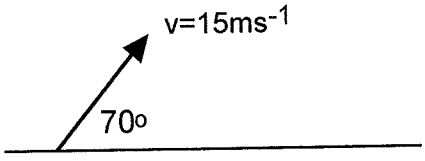
(a) This means that if I project an object vertically upwards with an initial vertical speed of $20ms^{-1}$ it will get to the same _____ (A) in the same _____ (B) as the actual projectile

(b) Also if I project an object horizontally with a horizontal velocity of $30ms^{-1}$ it will travel the same horizontal _____ (C) in the same time as the actual projectile

(2) A ball is kicked at an angle of 70^o to the horizontal at $15ms^{-1}$. Calculate

(a) The horizontal component of its velocity? ($5.1ms^{-1}$)

(b) The initial vertical component of its velocity. ($14.1ms^{-1}$)



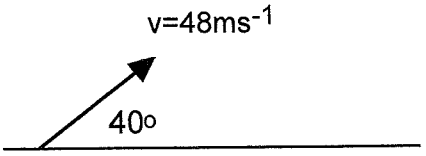
(c) The highest point of its trajectory. (10.1m)

(d) The time to reach highest point (1.4s)

(e) The total time it is in the air (2.8s)

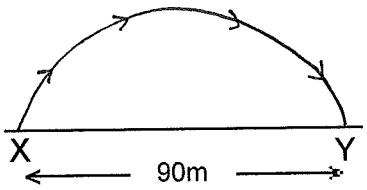
(f) The horizontal range of the ball. (14.3m)

(3) A golfer hits a shot as shown. Calculate



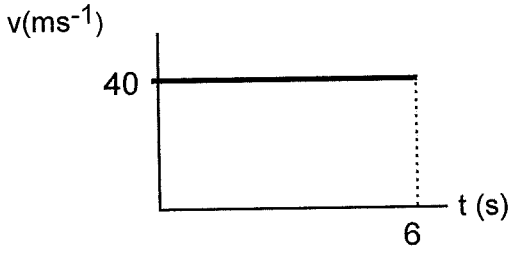
(a) The horizontal component of its velocity? ($36.8ms^{-1}$)
(b) The initial vertical component of its velocity. ($31ms^{-1}$)
(c) The highest point of its trajectory (49m)
(d) The time to reach the highest point (3.2s)
(e) The total time it is in the air. (6.4s)
(f) The horizontal range of the ball. (235.5m)

(4) A projectile takes 6s to travel from X to Y as shown It travels a horizontal distance of 90m. Calculate

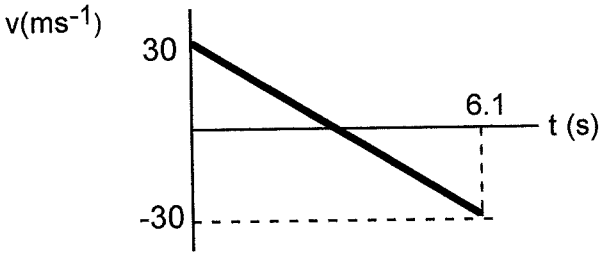


(a) The horizontal component of its velocity ($15ms^{-1}$)
(b) The initial vertical component of its velocity. ($29.4ms^{-1}$)
(Hint - how long to reach highest point)
(c) The maximum height reached. (44.1m)
(d) The actual velocity of the ball when released. 33ms-1 (63° above horizontal)

(5) The following graphs show the horizontal and vertical components of a ball which is projected obliquely.



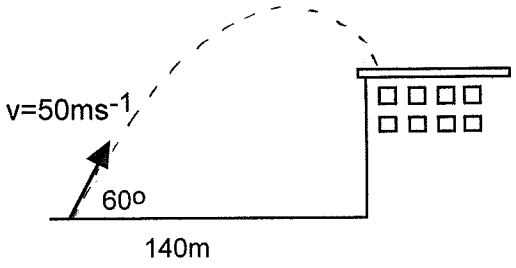
horizontal component



vertical component

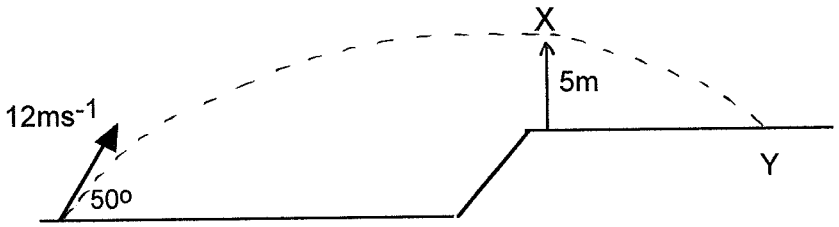
(a) What is the horizontal component of velocity? ($40ms^{-1}$)
(b) What is the initial vertical component of velocity? ($30ms^{-1}$)
(c) For how long was the ball in the air? (6.1s)
(d) How far did the ball travel horizontally? (240m)
(e) What was the maximum height of the ball? (45.8m)

(6) Firemen launch a hook onto the top of a burning building as shown. Calculate



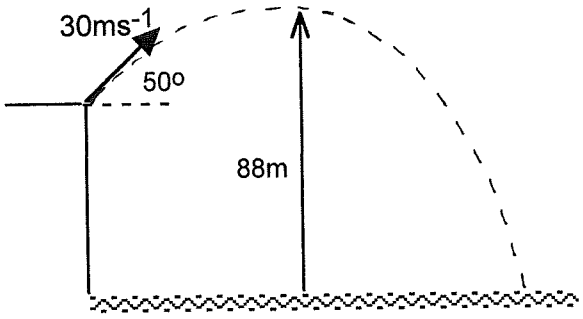
(a) The horizontal component of its velocity? ($25ms^{-1}$)
(b) The initial vertical component of its velocity. ($43.3ms^{-1}$)
(c) The time it takes the ball to land. (5.6s)
(d) The height of the building. (88m)

(7) A golfer strikes a shot onto a raised green as shown. The ball reaches its highest point at X and lands at Y.



(a) Calculate the horizontal component of its velocity? ($7.7ms^{-1}$)
(b) Calculate the initial vertical component of its velocity. ($9.2ms^{-1}$)
(c) How long was the ball in the air? (Hint - 2-parts - time to highest point and then time to fall onto green from highest point) (1.95s)
(d) The horizontal distance travelled (15m)

(8) The following life buoy is projected into the sea as shown



(a) The horizontal component of its velocity? ($19.3ms^{-1}$)
(b) The initial vertical component of its velocity. ($23ms^{-1}$)
(c) How long did it take to get to its maximum height. (2.35s)
(d) What was the total time it was in the air? (2.35 + 4.2 = 6.55s)
(e) What was the horizontal distance travelled? (126.4m)

OPEN ENDED QUESTION

(1) In all these projectile motion examples what one thing did we ignore and which one value was an approximation

Gravity

(1) Write down missing values V,W, X,Y and Z

The gravitational force between two masses is _____V_____ proportional to the _____W_____ of the distance between them and directly proportional to the _____X_____ of their masses. This means if you double the distance between two masses you _____Y_____ the force. And if you double one of the masses you _____Z_____ the force.

(2) Show that the gravitational force of attraction between two large ships, each of mass 5×10^{7}kg and separated by a distance of 20m is 417N.

(3) Calculate the gravitational force of attraction between two cars each of mass 1000kg which are parked 5m apart. (2.67×10^{-4}N)

(4) In a hydrogen atom an electron and proton are 5.3×10^{-11}m apart. Find the gravitational attraction between them? (me = 9.11×10^{-31}kg mp = 1.67×10^{-27}kg) (3.61×10^{-47}N)

(5) The sun has a mass of 1.99×10^{30}kg. The mass of the Earth is 5.98×10^{24}kg. If the distance between their centres is 1.5×10^{11}m calculate the gravitational force of attraction. (3.53×10^{22}N)

(6) Two protons each of mass 1.67×10^{-27}kg exert a gravitational force of 1.16×10^{-55}N. on each other. Calculate the distance between them. (4×10^{-15}m)

(7) A 60kg boy stands on the surface of Earth a distance of 6.37×10^{6}m from the centre

(a) Use W=mg to calculate his weight. (588N)
(b) Calculate the gravitational force of attraction between the boy and the Earth using the formula $F = \frac{GM_eM_b}{r^2}$ (589.8N)

(b) What is another name for this gravitational attraction?
(c) In the equation if F = W then what is another name for $\frac{GMe}{r^2}$

(8) The force of gravity between two binary stars which are a distance of 1.7×10^{15}m apart is 5×10^{27}N. If one star has a mass of 4×10^{33}kg what is the mass of the other? (5.4×10^{34}N)

OPEN ENDED QUESTION

For each statement use your knowledge of Physics to comment.

1. A pupil states that when he drops a stone the stone pulls the Earth up to it.

2. After doing question 5 above a pupil asks " If the gravitational force on the Earth is as calculated, won't the Earth be pulled into the sun and burn up"